

ECOLOGY AND BEHAVIOUR OF FRUIT FLY, *BACTROCERA PAPAYAE*
IN PENINSULAR MALAYSIA

BY

FARAG ABDALLA MUTTARDI

INSTITUTE OF BIOLOGICAL SCIENCE (ZOOLOGY)
FACULTY OF SCIENCE
UNIVERSITY OF MALAYA

DISSERTATION PRESENTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2000

Perpustakaan Universiti Malaya



A510475382

ECOLOGY AND BEHAVIOUR OF FRUIT FLY, *BACTROCERA PAPAYAE*
IN PENINSULAR MALAYSIA

BY

FARAG ABDALLA MUTTARDI

INSTITUTE OF BIOLOGICAL SCIENCE (ZOOLOGY)
FACULTY OF SCIENCE
UNIVERSITY OF MALAYA

DISSERTATION PRESENTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2000

Perpustakaan Universiti Malaya



A510475382

CONTENTS

Acknowledgement.....	I
Abstract.....	II
Abstrak.....	VII
Abbreviation.....	VIII
List of tables.....	IX
List of figures.....	XI
List of plates.....	XII
Chapter 1: General introduction	
1.0 Introduction.....	1
1.1 Culture of insects.....	12
1.2 Preparation of larval medium.....	13
Chapter 2: Demographic studies of fruit fly <i>Bactrocera papayae</i>	
2.1 Introduction.....	15
2.2 Material and Methods.....	16
2.3 Results.....	18
2.3.1 Adult longevity.....	18
2.3.2 Fecundity.....	18
2.3.3 Egg hatchability and fertility.....	18
2.3.4 Life history parameters.....	22
2.3.5 Life table parameters.....	22
2.4 Discussion.....	22
Chapter 3: Host preference choice between red, green chillies and duration of oviposition with or with out egg deposition	
3.1 Introduction.....	25
3.2 Material and Methods.....	26
3.3 Results.....	27
3.3.1 Oviposition activities of flies on chillies.....	29
3.4 Discussion.....	34
Chapter 4: Laboratory study of host preference	
4.1 Introduction.....	36
4.2 Material and Methods.....	37
4.3 Results.....	39
4.4 Discussion.....	39
Chapter 5: Effects of esterases and diets on mortality of <i>Bactrocera papayae</i>	
5.1 Introduction.....	43
5.1.1 Effect of adult nutrition on longevity of <i>Bactrocera papayae</i>	44
5.2 Material and Methods.....	45
5.2.1 Effects of Malathion and Dichlorvos.....	48
5.2.1.1 Extract and chemical preparation.....	48
5.2.2 Esterase detection.....	48
5.2.3 Effect of diet.....	48
5.3 Results.....	49
5.4 Discussion.....	57

Chapter 6: Environmental factors affecting the immature mortality of *Bactrocera papayae* in the soil

6.1 Introduction.....	60
6.2 Material and Methods.....	61
6.2.1 Cages.....	61
6.2.2 Treatments.....	62
6.3 Results.....	69
6.3.1 Larval pupal mortality due to fruit factors.....	69
6.3.2 Natural larval mortality in the soil.....	71
6.3.3 Larval pupal mortality due to soil factors.....	71
6.3.4 Physical factors of the soil.....	76
6.3.5 Biotic factors of the soil.....	77
6.3.6 Larval pupal mortality due to predators.....	78
6.3.7 Seasonal differences in the pupal mortality.....	79
6.4 Discussion.....	80

Chapter 7: Sexual communication of *Bactrocera papayae*

7.1 Introduction.....	87
7.1.1 Significance of the study.....	87
7.2 Material and Methods.....	89
7.2.1 Description of sexual behaviour.....	89
7.2.2 Sexual activities with respect to age.....	90
7.2.3 Responsiveness and receptivity of mated females.....	94
7.3 Results.....	94
7.3.1 Description of sexual behaviour.....	96
7.3.2 On sexual activities with respect to age.....	98
7.3.3 Responsiveness and receptivity of mated female.....	98
7.4 Discussion.....	102

Chapter 8: Male wing fanning for attraction and mating with female of *Bactrocera papayae*

8.1 Introduction.....	106
8.2. Material and Methods.....	110
8.3 Results.....	118
8.4 Discussion.....	127

Chapter 9: Criteras of a sexually successful male in *Bactrocera papayae*

9.1 Introduction.....	136
9.2 Material and Methods.....	138
9.2.1 Variation in male success.....	138
9.2.1.1 Attractiveness Experiment.....	138
9.2.1.2 Mating ability Experiment.....	139
9.2.2 Attractiveness and mating ability of males.....	139
9.2.2.1 Attractiveness Experiment.....	139
9.2.2.2 Mating ability Experiment.....	140
9.2.3 Sexually successful males.....	141
9.2.3.1 Attractiveness Experiment.....	141
9.3 Results.....	141

9.3.1 Frequency of sexually successful.....	141
9.3.2 Attractiveness and mating ability of males.....	141
9.3.3 Sexually successful males.....	144
9.4 Discussion.....	144
Chapter 10: General discussions and Conclusions	148
References.....	154
Appendices	182

ACKNOWLEDGEMENTS

I am most grateful to my supervisors, Associate Professor Dr. Mohd. Sofian Azirun and Dr. Rosli Hashim for their helpful advice, valuable suggestion, and guidance throughout the study. My thanks are also to Associate Professor Dr. Chua Tock Hing for his kind assistance at the beginning of the study.

I wish to thanks Professor Dato' Anuar Zaini Mohd. Zain, the Vice-Chancellor of University of Malaya, Professor Haji Mohamed Abdul Majid, the Dean of Faculty of Science and most, Professor Amru Nasrulhaq Boyce, the Head of the Institute of Biological Science for the working facilities provided.

I also would like to thank the Faculty's secretaries, and several friends in the Institute especially Mr. Omer Abdul Jalil, Tuan Haji Mokhtar Ibrahim, Tuan Haji Elias Megat Ahmad, Mr. Rosli Sarjan, Mr. Asokan, Miss Ng Shiow Ing and other staff for their assistance and friendship.

My most sincere thanks goes to my loving family for their encouragement and understanding. My special thanks are extended to my beloved wife and my son for being a continual source moral support and inspiration over these years of study.

ABSTRACT

Bactrocera (= *Dacus*) *papayae* bred from chillies collected from Klang (MARDI Station) and kept in laboratory cages, laid 5.6 eggs per female per day with a maximum of 34 eggs. The net egg hatchability was 46.2 % . Egg hatchability declined with age of females. The intrinsic rate of increase (r) was 0.1150 while the finite rate of increase (λ) was 1.13 .The net reproductive (R_0) was 170 female eggs per female, and generation time was 45 . The intrinsic rate of increase under laboratory conditions was similar to *Bactrocera* Malaysian A (bred from Star-fruit) and *B. cucurbitae* but higher than of *B. latifrons* .

Ovipositing females showed a distinct preference for riped fruits particularly, reddish orange colour over green chillies. Females seemed to be able to regulate egg laying according to availability of fruits. Hence the number of eggs laid per female was higher when exposed to 8 of chillies compared to 2,3 and 4 available chillies.

In a laboratory study on the suitability of fruits for larval development, 8 fruits species (papaya, guava, mango, banana, chilli, tomato, starfruit and eggplant) were selected to determine the fruits preferences as host. Papaya was the best preferenced fruit, It was found that peptone and yeast extract were the best diets for the fecundity and longevity .

The mean time (sec.) spent on oviposition activities of female upon arrival on a fruit were: 1) surface examining phase, 34 ± 3.2 (2) ovipositor probing and ovipositor insertion phase 192 ± 0.82 and (3) postoviposition phase 11 ± 0.56 ,

Adults were compared for resistance to Malathion and Dichlorvovous insecticies, the resistance to malathion 0.5×10^{-3} was higher than to dichlorvovous 0.5×10^{-3} . Electrophoresis was used for enzyme esterase bands comprising the resistance and

susceptible strains, Carboxylesterase (Car E) (3.1.1.1) detected at the adult stage. Both (α - β) naphthyl acetate was equally affective but β - naphthyl acetate was more affective and so suitable as substrate for esterase detection.

The strongest component of environment influencing the adult population of *B. papayae* was the availability of its favoured host fruits (papaya).

Three major parasitoids of *B.papayae* in papaya were *Biosters vandenboschi*, *B. longicaudatus* and *B. arisanus*. Relationships between total initial hosts (*B.papayae* immatures) and total hosts killed by each parasitoid species good correlation and parasitoids relationships were not density dependent.

The percentage of the larvae that survived through fruits factors was 84.2% in soil, the soil factors reduced survival to 21.3 %. Amongst the soil factors, weather accounted for 45.5 % biotic factors 16.5 % and physical factors 2.5 % of the mortality. Predator ants (*Dolichoderus* and *Componotus* sp.) 19.1 %.

Three major components in the sexual behaviour included (1) Signal emission through male - wing fanning followed by arrival of females, (2) Courtship behaviour involving male - wing fanning followed by attempted copulations; and (3) Copulation. Further test also showed that females that had mated once were neither attracted to males nor accepted subsequent mating as readily as virgin females.

By modifying either the male's ability in emitting sexual signals, i.e. modification of wing fanning or the various sensory receptors in the females, i.e. the eyes for visual signals, the aristae for acoustic stimuli, and the antennae for olfactory cues, it was possible to investigate the separate modalities of sexual communication during the (1) attraction phase (i.e. the bringing together of the two sexes over a distance of 50 cm) and 2) courtship phase (i.e. signal emission at close range of about 5 cm). The wing fanning in males was found to play a significant role in the production of

signals for the attraction of and mating with females . Experiments conducted in the females showed that acoustic as well as olfactory signals were crucial in attracting females to wing fanning males, but only olfactory stimuli were important for mating acceptance of the females. Differential sexual success among males and female choice played an important role in the complex mating system in this species. Sexual success in males was measured in terms of ability to attract and mate with females. For the most part , both qualities could be found in the same male. It was also found that sexually successful males had the capacity of signalling for a longer duration, and had top rank in male-male aggressive interactions more frequently than males. Thus inter-male competition could possibly be another component of sexual selection operating in this species .

Abstrak

Bactrocera (= *Dacus*) *papayae* membiak di dalam buah cili yang dikumpul dari Klang (Stesyen MARDI) dan disimpan di dalam sangkar-sangkar makmal, menghasilkan 5.6 biji telur per betina per hari dengan maksimum 34 biji telur. Penetasan bersih telur ialah 46.2%. Penetasan telur menurun dengan umur betina. Kadar Penambahan Asas (r) adalah 0.115, sementara Kadar Penambahan Terbatas (λ) adalah 1.13. Pembiakan bersih (R_0) adalah 170 biji telur per betina dan generasi masa ialah 45. Kadar Penambahan Asas di dalam keadaan makmal adalah serupa dengan *Bactrocera* Malaysian A (membiak di dalam buah belimbing) dan *B. cucurbitae*, tetapi lebih tinggi daripada *B. latifrons*.

Betina penelur menunjukkan pemilihan jelas terhadap buah cili yang masak dan merah, warna jingga-kemerahan berbanding dengan hijau. Betina memperlihatkan keupayaan mengatur peneluran bergantung kepada kesediaan buah cili tersebut. Oleh itu, bilangan telur yang dihasilkan oleh seekor betina adalah tinggi setelah didedahkan dengan 8 pasang buah cili berbanding dengan 2, 3 dan 4 ekor betina.

Kesesuaian buah-buahan untuk perkembangan larva ditunjukkan seperti siri berikut: betik > jambu > mangga > tomato > belimbing > cili > pisang dan eggplant (tumbuhan penelur). Di dalam perumah betik adalah yang paling sesuai, berat dan saiz kepompong adalah 12.9g, 5.1mm dan kitaran hidupnya adalah 19.5 hari. Di dalam perumah eggplant (tumbuhan penelur) yang kurang sesuai, berat dan saiz kepompong adalah 4.5g, 3.1mm dan kitaran hidupnya adalah 23 hari.

Dewasa diberi makan dengan 4 jenis sajian iaitu pepton, ekstrak yis, kasein dan madu. Pepton dan ekstrak yis adalah sajian untuk serangga perosak untuk kesuburan dan kelanjutan usia.

Tempoh peneluran untuk berjaya atau tidak masing-masing puratanya adalah 192 ± 3.2 dan 34 ± 3.2 . Aktiviti-aktiviti peneluran oleh betina sebaik sahaja singgah pada buah-buahan; 1) fasa pemeriksaan permukaan 2) fasa penerokaan ovipositor dan fasa penujahan ovipositor 3) fasa pasca-peneluran. Purata/min masa (saat) digunakan pada setiap fasa masing-masing 34 ± 3.2 , 192 ± 0.82 dan 11 ± 0.56 .

Perbandingan daya ketahanan dewasa terhadap racun serangga, Malathion dan Dichlorous, di antara organofosfat yang telah diuji, ketahanan terhadap malathion 0.5×10^{-3} lebih tinggi berbanding dengan dichlorous 0.5×10^{-3} . Elektroforesis telah digunakan untuk jenis-jenis enzim esterase yang merangkumi strain rintang dan strain rentan, Karboksilesterase (CarE) (3.1.1.1) dikesan pada peringkat dewasa. Kedua-dua (α - β) naftil asetat adalah sama berkesan tetapi β -naftil asetat lebih berkesan apabila digunakan sebagai substrat untuk pengesanan esterase.

Komponen persekitaran yang kuat mempengaruhi populasi *B. papayae* dewasa adalah kesediaan perumah buah-buahan yang sesuai. Dalam hal ini buah betik memainkan peranan yang penting.

Terdapat 3 jenis parasitoid yang penting bagi *B. papayae* di dalam buah betik iaitu *Biosteres vandenboschi*, *B. longicaudatus* dan *B. arisanus*. Perhubungan di antara jumlah mula perumah-perumah (*B. papayae* belum matang) dan jumlah perumah-perumah yang dibunuh oleh parasitoid setiap spesies adalah korelasi yang baik dan perhubungan parasitoid adalah kebergantungan kepada kepadatan.

81.9% larva di dalam buah betik terus hidup di dalam tanah, kematian semulajadi mengurangkan keterushidupan kepada 75.0%, sementara faktor tanah mengurangkannya kepada 21.3%. Di kalangan faktor-faktor tanah yang menyebabkan kematian, faktor cuaca diambil kira iaitu 45.5%, faktor-faktor biotik

33.3% dan faktor-faktor fizikal 2.5%. Pemangsa seperti semut (*Lamponofus* sp., *Dolichoderus* sp. dan *Componotus* sp.) 18.9%.

Tiga (3) komponen penting di dalam kelakuan seksual termasuk 1) Penonjolan isyarat melalui jantan-sayap dikipaskan, diikuti oleh kedatangan betina-betina 2) Kelakuan pemikatan membabitkan jantan-sayap dikipaskan, diikuti oleh percubaan kopulasi dan 3) Kopulasi. Ujian seterusnya juga menunjukkan betina-betina telah berpasangan sekali sama ada tertarik kepada jantan-jantan atau menerima persenggamaan berikutnya sebagai betina-betina yang dara.

Dengan mengubahsuaikan sama ada keupayaan jantan di dalam menonjolkan isyarat-isyarat seksual iaitu pengubahsuaian kipasan sayap atau pelbagai deria penerima di dalam betina, iaitu mata untuk isyarat-isyarat visual/penglihatan, aristae untuk perangsang bunyi dan antenna untuk isyarat bau, ianya membolehkan penyiasatan modality perhubungan seksual berasing semasa 1) fasa tarikan (iaitu membawa 2 jantina yang berbeza bersama-sama pada jarak 50cm) dan 2) fasa pemikatan (iaitu penonjolan isyarat pada had yang dekat, lebih kurang 5cm). Kipasan sayap pada jantan ditemui memainkan peranan penting di dalam isyarat pembiakan untuk menarik perhatian dan bersanggama dengan betina. Ujikaji dijalankan ke atas betina dan ianya menunjukkan bahawa isyarat bunyi dan bau sama penting untuk menarik betina kepada kipasan sayap jantan, tetapi hanya rangsangan bau penting untuk menerima persenggamaan oleh betina. Perbezaan seksual di kalangan pemilihan jantan dan betina yang berjaya, memainkan peranan yang penting di dalam system persenggamaan yang kompleks untuk spesies ini. Kejayaan persenggamaan di dalam jantan ditentukan dalam bentuk keupayaannya menarik dan bersanggama dengan betina. Dengan demikian persaingan jantan yang berbeza boleh jadi komponen lain di dalam operasi pemilihan seksual bagi spesies ini.

Abbreviation

Ali E.....	Aliesterase
Ar E.....	Aromatic esterase
Aryl E.....	Arylesterase
^o C	Centigrade
Car E.....	Carboxylesterase
Ch E.....	Colinesterase
cm.....	centimetre
DDVP.....	Dichlorvos
EDTA.....	Ethylene Diamine Tetraacetic Acid
Fig.	Figure
h.....	hour
IBSEF.....	Institute of Biological Science Experimental Farm
M.....	Molar
m.....	meter
mm.....	millimeter
RH.....	Relative Humidity
Sec.	Second
Sign.	Significant
SIRM.....	Sterile Insect Release Method
OP.	Organophosphate
PO ₄ buffer.....	Phosphate buffer
UM.....	University Malaya
UPM.....	University Putra Malaysia

List of Tables

Table	Page
1. Formulae for the calculations of fruit flies reproductive parameters	17
2. Parameters and other statistics on reproduction and survivorship of <i>Bactrocera papayae</i> reared in the laboratory on 3: 1 sugar: peptone, water and honey Gross value take consideration adult mortality, while net value does not Fecundity refers to total eggs production while the fertility considers the eggs hatched.	21
3. Population parameters (mean of two replicates) of <i>Bactrocera papayae</i> Value for other <i>Bactrocera</i> spp. Included for comparison	23
4. Comparison number of eggs record in red (R) and green (G) chillies in choice experiments of different densities of fruit fly <i>B.papayae</i> a total of fifteen replicates was for each treatment	28
5. Comparison number of larva record in red (R) and green (G) chillies in choice experiments of different densities of fruit fly <i>B.papayae</i> a total of fifteen replicates was for each treatment	30
6. Relation between duration of (A) ovipositor insertion and (B) egg deposition	31
7. The life cycle of <i>B.papayae</i> on different host fruits. (the development duration of <i>B.papayae</i> on different host fruits Each treatment was three times. Each mean basal for 15 individuals)	40
8. Mean Pupal size weight, percentage of adult emergence of <i>B.papayae</i> from different fruits (n - 30)	41
9. Longevity and oviposition of mated individuals of <i>B.papayae</i>	55
10. The percent eggs hatch and adults emerge of <i>B.papayae</i>	56
11. Predation of <i>B.papayae</i> (means + s.e) # in Petaling jaya (UM) and Serdang (UPM)	70
12. Larval and pupal mortalities (means + s.e) * of <i>B.papayae</i> in soil in Petalingjaya, Serdang	72
13. The effect of first mating on the approach by <i>B.papayae</i> females to males during the period of the 2 - 18 days	99
14. The effect of first mating on the subsequent mating behaviour of <i>B.papayae</i> females during the period 1-18 days after mating in the presence of virgin females.....	100

15. The effect of first mating on the subsequent mating behaviour of <i>B.papayae</i> females during the period 1- 18 of days	101
16. Wing fanning attractions between sexes of <i>B.papayae</i>	119
17. Females attraction to males possessing non modified or modified wings	122
18. Females attraction possessing non modified or modified sensory receptors to males.....	124
19.The mating success of males with modified or non-modified wings.....	125
20. Matings males possessing non modified or modified wings under all possible combination	126
21. Effects of sensory receptor modifications in female mating	128
22. Females matings possessing non modified or modified sensory receptors under all possible combinations	129
23. Variation in male sexual success (both attraction and mating)	142
24. Success of <i>B.papayae</i> male in attracting and mating with females	143
25. Attraction of females in 30 min. observation period in relation to mating.....	145

LIST OF FIGURES

	Page
1 Survivorship curves of adult <i>Bactrocera papayae</i>	19
2 Oviposition of female <i>B. papayae</i>	20
3 Ovipository activities of <i>B. papayae</i> females on chilli fruit	32
4 Influence of diet on oviposition rate of <i>B. papayae</i>	52
5 Fecundity <i>B. papayae</i> fed on 4 different diets	53
6 Enzymogram of esterase for adult <i>Bactrocera papayae</i> A. <i>In vivo</i> inhibitors and B. <i>In vitro</i> inhibitors	54
7 Cumulative percentages of mating (a) males (b) female at various ages	97
8 Distribution of female response to wing fanning by males at 5 min. intervals between 1730 and 1930 period.....	121
9 A diagrammatic representation of <i>Bactrocera papayae</i> of life system	150

LIST OF THE PLATES

	Pages
Plate 1: Atypical laboratory cage (30 × 30 × 30 cm ³) for maintaining adults papayae in the laboratory	14
Plate 2: Laboratory cage (1 × 1 × 1 m) ³ Top show the host before the flies exposure Bottom At starting the flies exposure	38
Plate 3: Comparison of the α - β esterase after the adult <i>B.papayae</i> were exposed to Inhibitors Malathion and Dichlorvos, A. In vivo B. In vitro (Top β- esterase and Bottom α- rsterase)	50
Plate 4: Type B cage 2 which used to isolate all predators from <i>Bactrocera</i> <i>papayae</i> immatures in papaya fruits (top) at the starting the experiment (bottom) show placement of one sticky trap into the cage	63
Plate 5: Type C cage 3 which was used to expose <i>Bactrocera papayae</i> immat-ures in the papaya fruits at starting of the experiment (top) and the cage covered after three days (bottom).....	64
Plate 6: Type D cage 4 which was used to expose <i>Bactrocera papayae</i> immat-ure in the papaya fruit to all predators: top at the starting of the experiment middle show placement of one sticky trap into the cage bottom at end of the experiment	65
Plate 7: <i>Biosteres arisanus</i> (Sonaus) parasitoid of <i>Bactrocera papayae</i> eggs	73
Plate 8: <i>Biosteres vandenboschi</i> (Fullaway) parasitoid of the first instar larvae of <i>Bactrocera papayae</i>	74
Plate 9: <i>Biosteres longicaudatus</i> (Silvestri) parasitoid of <i>Bactrocera papayae</i> larvae (attacks all stages of larvae).....	75

Plate 10: Laboratory mini cages (5 cm diameter & 6 cm height).....	91
Plate 11: Laboratory cages (1 × 1 × 1 m) ³ with mini cages containg flies were hung on pot of chillies and tomatos (top) and at starting of the experiment (bottom)	112
Plate 12: Wing diagram of male (top) showing the portion medium (> 50%) and bottom (< 50%) that were removed	114
Plate 13: Colours which was used for painting	116